# The “Quantum Suite”

HPC Quantum Computing Emulators on Leonardo

*Sara Marzella*

CINECA QUANTUM COMPUTING LAB

# Quantum Computing Lab

https://www.quantumcomputinglab.cineca.it/

The **Quantum Computing Lab** is a new initiative by **Cineca** with the aim to investigate and develop **Quantum Computing tools integrated with HPC systems**

- **Study, assess and monitor** the progress of this state-of-the-art, promising technology fostering **interactions** between **QC experts**
- Test the applicability of the numerous **quantum devices** currently available by **developing algorithms** capable of addressing problems of great interest, such as optimization, chemical simulations and Machine Learning
- Develop **hybrid protocols**, where **Quantum Computing** is used as a support and accelerator for **Cineca's HPC systems**
- **Facilitate the discussion** between **universities**, **research centers** and **private parties** interested in QC applications
- **Support research** by providing access to **quantum computational resources** and facilities made available to researchers
- **Assist companies** in their pivotal efforts to initiate the QC transition
- Stimulate both the HPC and QC communities through a **series of conferences**, **educational courses** and **technical reports** on the usage of the latest QC **softwares** and **hardwares**

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# Cineca Quantum Computing Lab

## Teaching, Outreaching and Dissemination

CINECA ACADEMY

## European and National projects

HPC|QS

ICSC Centro Nazionale di Ricerca in HPC, Big Data and Quantum Computing

QUANTUM COMPUTING AND SIMULATION CENTER

QUANTUM COMPUTING LAB

## Quantum Computing Resources

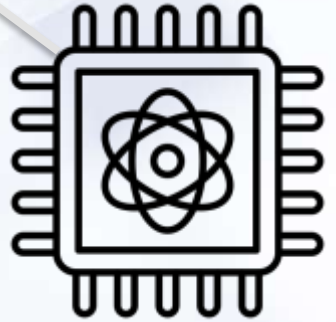
Cloud QC

D-Wave The Quantum Computing Company™

?

PASQAL

## Hybrid HPC-QC System

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# Quantum As A Service in CINECA

https://www.hpc.cineca.it/services/iscra

ISCRA
CINECA

- **ISCRA-C**: Quantum Computing
  - **D-Wave Quantum Annealer**
    - Available calculation hours to be used on D-Wave quantum machines
    - More than 30 projects already approved
- **Scientific collaboration with Pasqal**
- **HPC Emulators –Leonardo – «Quantum suite»**
  - **Opensource Emulators** (Qutip, Qiskit, Pulser, Cirq)
  - **Developing HPC – Multinode/MultiGPU Emulators**
    Tensor Network Emulators (Quantum Matcha Tea), State Vector Emulators, Analog Computing Emulators
- **Integration with Neutral Atoms QC***
- **MORE RESOURCES ARE COMING!**

D-Wave
The Quantum Computing Company™

PASQAL



*" Logical quantum processor based on reconfigurable atom arrays" https://www.nature.com/articles/s41586-023-06927-3

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EuroHPC
Joint Undertaking

# The EuroHPC JU has selected six sites across the European Union to host and operate the first EuroHPC quantum computers in:

- Czechia
- France
- Germany
- Italy
- Poland
- Spain

# EuroQCS - Italy

## First half 2023: Leonardo

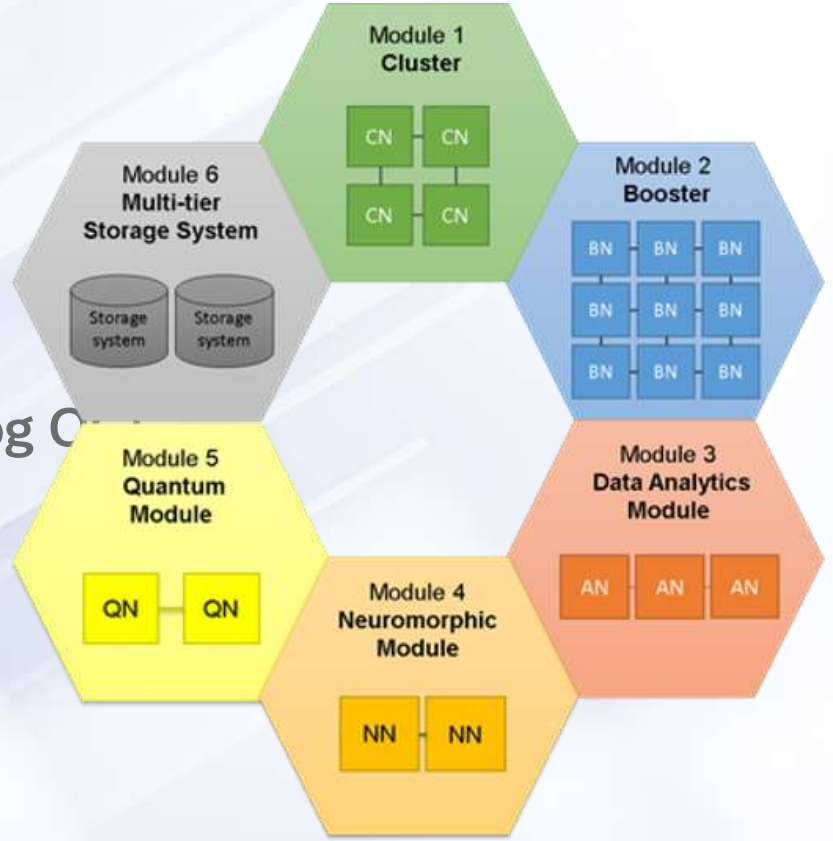
- Sixth most powerful supercomputer in the World
- 255+ petaflops (peak performance)
- Modular Supercomputing Architecture (MSA)

## End 2024 – Mid 2025: Quantum Module

- Integration of a Neutral Atoms Quantum Simulator (analog C

## End 2025 – Mid 2026: QM enhancement

- Enabling digital and mixed analog/digital mode

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# «Quantum Suite» on Leonardo

1. Load Quantum Profile - module load profile/quantum
2. Choose your favorite library/SDK:
   - Cirq (Google) – module load cirq
   - Ocean (D-wave) – module load ocean
   - Qiskit (IBM) – module load qiskit
   - Pulser (Pasqal) – module load pulser
   - Qibo – module load qibo
   - Pennylane – module load pennylane
   - Quantum Matcha Tea – module load qmatcha_tea

# Quantum Matcha Tea

Quantum Computing HPC friendly emulator

- National Center spoke 10 project
- In collaboration with University of Padua
- Tensor Network emulator
- Emulation of big circuits with moderate entanglement
- HPC friendly, integrated with CPUs and GPUs

More info at 15:45 with Marco Ballarin from University of Padua...stay tuned!

# Quantum Computing Lab Team

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